Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 129 (2015) 977 – 980

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering

Application of Technical and Economic Criterion of Equipment Control with Sucker Rod Pump

Sadov V.B.[a]*, Plotnikova N.V.[b]

[1]*Rabotnits, 72-24, Chelyabinsk, 454084, Russia*
[2]*Gryazeva, 8, Chelyabinsk, 454082, Russia*

Abstract

An approach to the synthesis of control algorithms of equipment with drive sucker rod pump is given on the basis of the analysis of the existing control principles. This approach uses the criterion including technical and economic component of oil production. Connections with diagnostic system of equipment in the control process are described. The principles of restrictions formation on control when using this criterion are given on the basis of operation results of embedded diagnostic system. The information system in the control structure of oil production is shown with application of the synthesized criterion, components of this system are described. This approach to the control synthesis of oil production can be extended onto some other types of equipment of oil production.

Peer-review under responsibility of the organizing committee of the International Conference on Industrial Engineering (ICIE-2015)

Keywords: **e**quipment with the drive sucker rod pump, control, an information structure of control system.

1. Introduction

Recently, questions of industrial automation in oil branch often connect with implementation of "smart" deserted technologies, "intellectual slits" which control systems are able to select itself the modes of oil pumping from a slit depending on the slit parameters and external conditions. The main aims of control systems of oil production are the

* Corresponding author. Tel.: +7-902-600-18-77.
E-mail address: sv_2005@inbox.ru

Peer-review under responsibility of the organizing committee of the International Conference on Industrial Engineering (ICIE-2015)
doi:10.1016/j.proeng.2015.12.154

decrease of the extraction cost of a unit of production and the general direct and indirect costs on slits exploitation. It means increase of coefficient of the oil recovery, reduction of coefficient of the pumping equipment depreciation, etc. Different control algorithms are used for control of installations with the drive sucker rod pump (DSRP) in an automatic mode. Value of "residue" on a plunger dinamogramm in case of insufficient fluid influx to slit is used as criterion in control systems of Lufkin Automation SAM Well Manager Variable Speed Drive firm. Practically it means that the system is retained in the mode on the boundary where the quantity of the moves is maximum for an accurate identification of defect appearance "insufficient fluid influx in a slit", determined at the plunger dinamogramm. The results of research of control stations of Lufkin firm [1] show that the power consumed by equipment decreases by 20%, exploitation costs of slits and equipment decrease by 25%, and production increases and equipment downtimes decrease only by 1-4% in case of use of the Lufkin Controller Well Manager RPC controller.

There are control systems of drives of Danfoss firm of the mechanized oil production of SALT (Sensor less Artificial Lift Technology) on technology without sensors where load data when using the frequency controlled drive for regulation of the pump delivery are used. Load is analyzed during regulation and the speed of the movement decreases or increases when it is necessary [2]. Thus both drive sucker rod pumps, and screw and submersible electrocentrifugal pumps can be used as pumps.

The main drawback of the given control algorithms of pump equipment is the lack of the direct link with main goals of control systems of oil production. It doesn't allow to change the level of oil production depending on the current parameters of the extracting equipment and economic components of oil production.

2. Synthesis of control algorithm of pump equipment

Synthesis of algorithms and control systems depends on a field of system application [3].

There is a method [4] in which the maximum of the criterion including components of production level, expenses on the electric power and exploitation of the deep equipment and drive sucker rod pump is defined for formation of level of the current production for borehole equipment with DSRP

$$G = q - k_1 \cdot (n + \alpha \cdot n^2) - k_2 \cdot n\,, \tag{1}$$

where q – the value of the current production in a unit of time (current productivity of a slit) or its assessment;

n – the current quantity of the double moves per minute of the drive of the drive sucker rod pump;

$M = k_1 \cdot (n + \alpha \cdot n^2)$ – the value characterizing the expenses on the electric power in a unit of time;

$D = k_2 \cdot n$ – the value characterizing the expenses on exploitation of the deep equipment and the drive of the drive sucker rod pump in recalculation per unit of time.

The scaling coefficients k_1 and k_2 have the dimensions resulting economic components in dimension of the current production in a time unit.

Constants k_1, k_2, α can be received on the basis of expert estimations. They can change depending on the price of oil (the oil production price), price of electricity, the price and the cost of exploitation of the deep and pump equipment.

It should be noted that it is necessary to consider the restrictions on the controlling variable (quantity of the double moves) because of characteristics of the DSRP drive and characteristics of an oil well, oil layer and the pumped-out liquid under search of a maximum of criterion (1). It is necessary to use diagnostic system in the controller of the control system of a well oil production. The conclusions about restrictions on the controlling variable and opportunity or expediency of further work of pump equipment (for example, during the diagnostics of a break of a rods column) in certain cases are drawn by the results of operation of this diagnostic system.

For example, during algorithm work the restriction of quantity of the double moves was 6 and step was changed from 4 to 4,5 double moves as a result of the work of adaptive algorithm. Thus the diagnostic system gave out the result" insufficient inflow of liquid to a well" for this value. It is necessary to change the restriction of quantity of the double moves to the value 4,5 as the increase of moves quantity relative to this value is inefficient. It is necessary to act similarly if insufficient inflow of liquid to a well hasn't been revealed during the work of the algorithm, but the

current restriction of the moves quantity is less than technological one and the outlet after the boundary of the current restriction of the quantity of the double moves has taken place. It is expedient to build the diagnostic system using the results of the dinamograms and vattmetrograms assessment because these approaches are most studied.

3. Synthesis of information system of equipment of oil production

As a rule, modern control systems have communication with shop information system. In most cases this communication has one-sided character: in spite of the fact that requests and answers from shop information system go diversely, information moves from a control system to shop, and from shop there are only requests for data acquisition, for example, of dinamograms and vattmetrograms data, equipment work parameters, etc.

If criteria of oil production control (1) are used during control information exchange in the direction shop information system – the control system of oil production becomes expedient. In this direction it is possible to transfer information which will lead to change the oil production parameters or even to change the modes of oil production. It is connected with the terms "intellectual field" and "intellectual well" which, obviously, shouldn't be autonomous and have to be closely connected with each other at the solution of the general problem of minimization of expenses on production of one ton of oil and various private tasks solved at each control level. Correction of those information streams which exist now in structure of control of oil production is required.

It is expedient to break all information system into groups with definition of connections between them. This structure is presented in figure 1 [5].

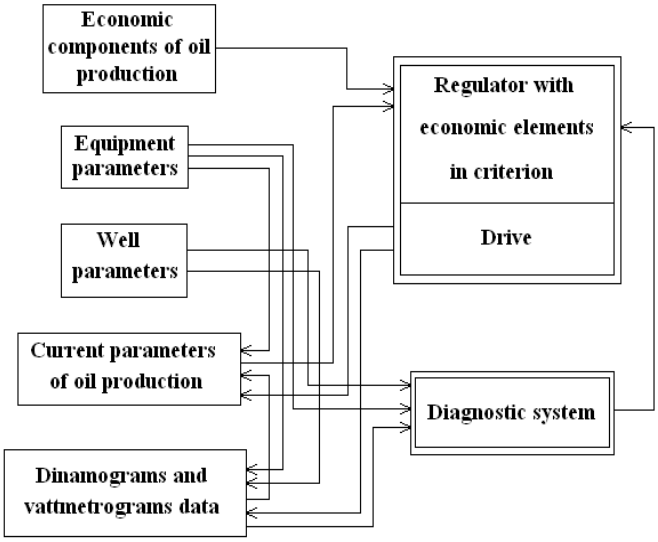

Fig. 1. Information connections in a control system of DSRP.

Information groups in the system are shown in the figure at the left. Modules of hardware-software part of a control system are shown on the right by double lines. We will consider components of this system. The block of economic components of oil production contains only coefficients of the expenses entering in the control criterion in the automatic mode and is connected with the control system regulator. The values of criterion change during change of data of this block and the control system respectively reacts on it by change of the control action (in our case the quantity of the double moves changes).

The block of equipment parameters is individual for each type of the DSRP and contains such values as length of the move of the polished rod, the area of the piston of a hydraulic cylinder at the gidrofikational drive, etc. These parameters influence on the parameters of the block of the current parameters of oil production (for example, an

estimation of the value of the current productivity of equipment), on the block of dinamograms and vattmetrograms data (for example, on the calculated values of points of the plunger dinamogram received from the estuarial data), and on the diagnostic system (for example, during estimation of the current loading in a column of rods).

The block of the well parameters contains such values as depth of immersion of the pump, level and characteristics of the pumped-out liquid, characteristics of the pump and a column of rods, etc. Parameters of this block influence on the diagnostic system (for example, during estimation of the minimum value of load of a column of rods), on the block of dinamograms and vattmetrograms data (for example, on the calculated values of points of the plunger dinamogram received from the estuarial data).

The block of the current parameters of oil production contains the current data of equipment operation (for example, the current measured quantity of the double moves) and estimated data of results of oil production (for example, exploitation productivity). Parameters of this block influence on operation of the regulator as, for example, the value of productivity estimation is included into the value of criterion of automatic control of exploitation.

The block of dinamograms and vattmetrograms data contains the dinamograms data (estuarial and, perhaps, plunger, received as a result of calculation) and archives of these data for its subsequent output via connection channels or to internal devices of indication. Dinamograms and, perhaps, vattmetrograms are used for the delivery of results of quality estimation of oil production and the equipment of a well in diagnostic system. Such information division into groups will allow to use the uniform structural units at data transmission from/in a control system of the drive regardless of DSRP drive type. Filling of blocks will depend on the type of DSRP drive and, perhaps, on pump type.

4. Conclusion

The new method of synthesis of control of the oil production equipment with the drive sucker rod pump is given. This approach is suitable as well in the case of use of pumps of other type, for example, of the electrocentrifugal.

References

[1] I.F. Zubairov, Intellectual well – increase of efficiency of the mechanized production, J. Engineering Practice. 5 (2011) 84─89.
[2] Information on http://www.danfoss.com/NR/rdonlyres/90BCF710-9C97-4F9C-9EF5-F9274DA9A842/0/salt_broshyura.pdf
[3] N.V. Plotnikova, Formulation of synthesis problem of quasistationary stochastic system, J. Bulletin of the South Ural State University, Ser. Computer Technologies, Automatic Control, Radio Electronics. 3 (2009) 68─71.
[4] V.B. Sadov, A.L. Shestakov, Automatic control of equipment of the borehole sucker rod pump, J. Oil Economy. 1 (2015) 98─101.
[5] V.B. Sadov, Synthesis of information system of installation of the borehole sucker rod pump, Proc. of IV Int. Sci. Conf., Topical Issues of Development of Science in the World. (2015) 51─53.